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sions can be drawn. There is no explanation offered for the apparent discrepancy between the penetration through six inches of ice and that through eight inches. This part of the study is altogether preliminary and will be rechecked. The data are presented as recorded.

TABLE IV. LIGHT PENETRATION THROUGH ICE

Thickness of Ice	Incident Illumination in Foot-Candles	Percentage of Penetration
4 in.	3700	86
6 in.	3300	66
8 in.	4400	74
14 in.	3900	33

Summary and Conclusions

The fraction of light penetrating a snow cover decreases rapidly as the thickness of the snow increases. It is imperceptible at a depth of eight inches, and cannot be accurately estimated with the aid of a light meter at seven inches.

Dirt, soot, granular condition, and wetness are all factors which tend to diminish penetration of light through snow.

The fraction of light penetrating a snow cover is less at low levels of incident illumination than at high levels indicating a difference in quality as well as in intensity of light.

A large fraction of incident light penetrates a clear ice cover at the depths coming under observation in this study.

It would seem from these data that sufficient light penetrates ice to permit photosynthetic activities of most water plants. Where the ice is covered by a layer of snow, it is doubtful as to whether the illumination would be adequate.

GEOLOGICAL CONDITIONS RESPONSIBLE FOR THE DEFICIENCY OF UNDERGROUND WATER IN CERTAIN AREAS IN MINNESOTA

ABSTRACT

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During the past few years there has been an increasing demand for relatively large amounts of underground water in regions where sub-surface rock formations are of such a character that large quantities of water cannot be produced. With the expansion of the Federal and State Park Systems and of the State Forestry Department, numerous camps for the Civilian Conservation Corps were established in northeastern Minnesota in areas where previously very

little sub-surface water was used. The United States Department of Health specified that the camps were to be supplied with underground water. Consequently several wells were drilled to depths as great as 600 and 800 feet. These wells were abandoned because they did not produce the volume or the quality of water required.

Similar difficulties were encountered in Jay Cooke Park, southwest of Duluth, and in Fort Ridgley State Park, northwest of New Ulm. The reasons for these deficient supplies of water became apparent when the subsurface geological formations were considered.

All rocks contain more or less water, but the conditions of the occurrence of the water in various types of rocks differ widely. Ancient crystalline rocks are very dense and possess very small pore spaces. Most of these rocks hold very little water. Clays and shales usually contain large quantities of water but their pore spaces are so fine that water circulates through them so slowly that they are impervious to the extent that little or none of the water they contain can be utilized as a source of supply. Slate, like clay, is a poor water producer, but it may yield relatively large supplies from crevices, joints, and cleavage planes. Sandstone is by far the best water producer of the solid rocks. Its porosity may be as high as 35% and commonly the pore spaces are sufficiently large to allow rapid circulation. Consequently wherever it is struck by a drill below the regional ground water table it yields water freely.

Most of the state of Minnesota is covered by a layer of glacial drift that varies from a few feet to more than 600 feet in thickness. Drift is a heterogeneous mixture of clay, sand, gravel and boulders. Texturally it varies from porous sands to impervious clays that are not definitely bedded. Consequently the water that it contains generally occurs in irregular channels. Locally, however, it is distributed throughout sandy beds. The glacial drift is the common source of supply of water in the rural districts over large areas throughout the state.

The accompanying geologic map of Minnesota shows that more than half of the state is underlain by ancient pre-Cambrian igneous and metamorphic rocks. These rocks occur from central Minnesota northward to the Canadian border. Over this entire area, underground water supplies must be obtained from the glacial drift. In the west central and northwestern part of the state the drift is sufficiently thick to furnish ample water for domestic and industrial purposes. In northeastern Minnesota, however, the drift sheet over the crystalline rocks is very thin and over large areas the glaciated bed-rock crops out at the surface. It is in such areas that the subsurface water-supply problem has become acute. A few cases are cited briefly, to illustrate the problem.

(1) The United States Forest Service has acquired a large acreage of unimproved land in the region to the north of the Mesabi Range. Water Supplies are needed for the Civilian Conservation

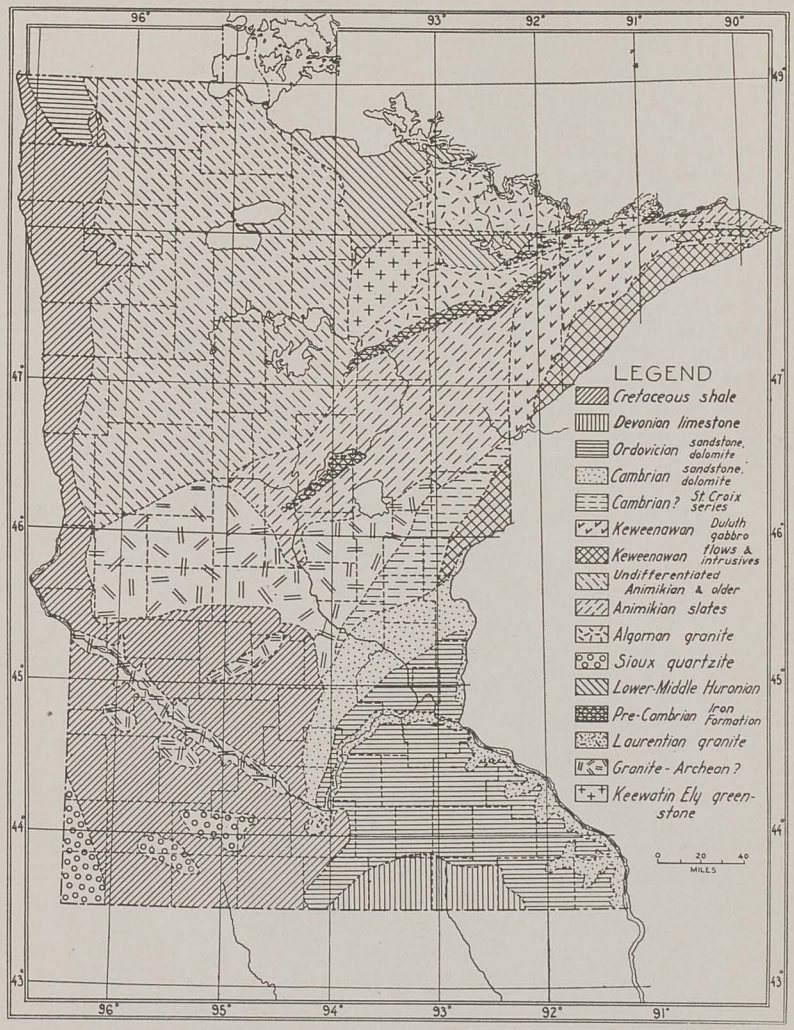

FIG. 1. GEOLOGIC MAP OF MINNESOTA. (REDRAWN FROM MAP BY THE MINNESOTA GEOLOGICAL SURVEY, PUBLISHED 1932)

Corps workers in the region. A number of the camps are built in areas where granite rock crops out on the camp grounds. Subsurface water supplies are quite inadequate.

(2) A few miles northwest of the City of Duluth a Federal Resettlement Project has been established. More than one hundred homes have been built on a 1,400 acre tract. Each home has its own water supply system. The geologic map shows that the region is underlain by the Keweenawan Duluth Gabbro. Test drillings indicate that this impervious bed rock is covered with less than twenty-five feet of glacial drift in the region of this project. The amount of subsurface water available for the new homes is very limited.

(3) In Jay Cooke Park along the valley of the St. Louis River, southwest of Duluth, a thin layer of glacial drift is deposited over impervious slates. A public water supply for park visitors is desired. The water must be obtained from a shallow well in the glacial drift. A deep well drilled 1,100 feet into the slates at the City of Carlton failed to produce a supply for that city.

(4) Over large areas in central Minnesota a thick mantle of residual white clay occurs above the unaltered bed-rock. In some localities the clay is covered with clayey drift derived from the Cretaceous shales of northwestern Minnesota and the plains of west central Canada. Where such a succession of clayey sediments is encountered over an impervious bed rock, only small quantities of ground water can be expected.

COMPOSITE AEROSTAT VS. CHARLES BALLOON
(By Title Only)

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IMPORTANCE OF STUDY OF PREVAILING WINDS IN STRATOSPHERE AND SUBSTRATOSPHERE
(By Title Only)

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CHARACTERISTICS OF A HIGH QUALITY RADIO LOUDSPEAKER *(By Title Only)*

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